(12) UK Patent Application (19) GB (11) 2 187 217 (13) A

(43) Application published 3 Sep 1987

(21) Application No 8700329

(22) Date of filing 8 Jan 1987

(30) Priority data

(31) 61/008282 (32) 23 Jan 1986 (33) JP

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(51) INT CL[4]
D07B 1/02

(52) Domestic classification (Edition H)
D1T 1B 1H 1M

(56) Documents cited
GB 1558510 GB 1417394 GB 1196078
GB 1045997 GB 0897155 GB 0891768
GB 0738869 GB 0731812 GB 0721879

(58) Field of search
D1T D1W
Selected US specifications from IPC sub-class D07B

(54) Metallised string for rackets, instruments, fishing, etc

(57) The string comprises a main body of synthetic fiber and a metal film coating the main body over at least part of the surface thereof. Monofilaments can be wound in a layer around a monofilament core. The metal film is then formed over the surface of the resulting assembly, or over the surface of the core and the surface of the wound monofilaments. The body may comprise twisted multifilaments. The synthetic fibre may be one or more of polyester, polyamide, fluorocarbon and polyolefin fibres. Metals for the coating are listed. The metal film gives the string greatly improved resistance to abrasion, water and light.

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Fig.1

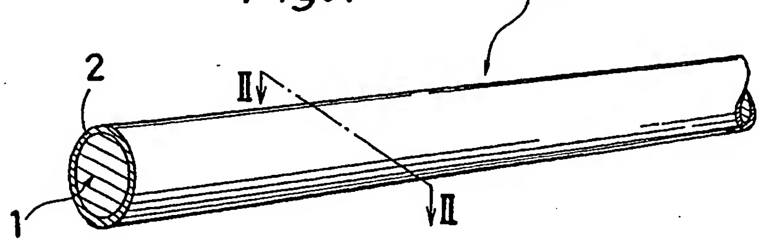


Fig.2

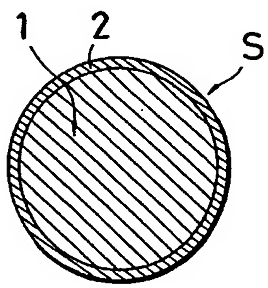


Fig.3

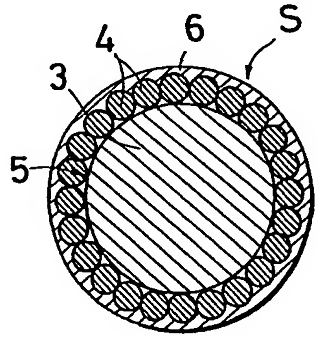


Fig.4

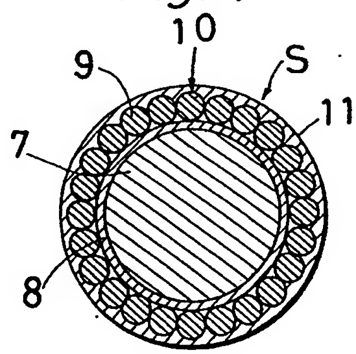


Fig.5

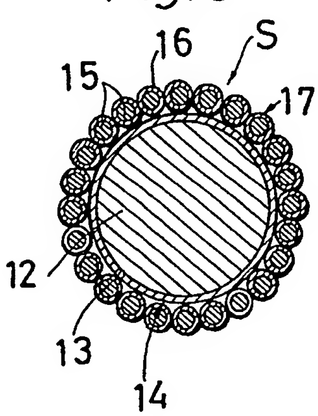


Fig.6

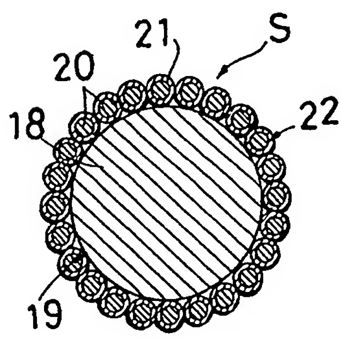
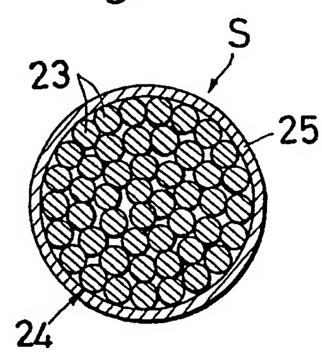


Fig.7



SPECIFICATION

Stringf r rackets, stringed instruments, fishing, etc.

Strings of synthetic fibers such as polyamide and polyester fibers are generally used at present as strings for tennis and like rackets, stringed instruments, etc. in place of those made of natural material, such as guts and strings obtained from whales, which were used for a long time. Similarly, various synthetic fibers are used in place of natural materials for fishing lines and fishing nets.

Strings of synthetic fibers have many advantages over those made of natural material; more abundant materials are available, and the strings are inexpensive and easy to make and generally have high strength. However, they still remain to be improved in resistance to abrasion and to light and are not fully satisfactory in durability.

When this problem is considered, for example, in the case of the string for tennis rackets, it is noted that the string is liable to break owing to the friction between the main string portion (so-called main string) and the cross string portion (cross string). This drawback is attributable to the following two causes.

(1) When the head of the racket is to be stringed, the string is stretched first lengthwise thereof and then crosswise. When setting a cross string in place, the cross string is forcibly pulled quickly in frictional contact with a particular portion of each main string, consequently forming a U-shaped indentation in the main string. In an extreme case, it is likely that the main string will be damaged to a depth approximate to one-half of its diameter. If the racket is used in this state, the impact of the ball breaks the main string in a short period of time.

(2) When hitting the ball, the racket is frequently moved transversely thereof to give a rotation to the ball. Every time the racket is swung in this manner, the ball is liable to displace some main strings in frictional contact with cross strings. Consequently, a flaw develops in a particular portion of the main string to break the string at this portion.

To obviate the above problem, silicone oil, wax or like lubricant is conventionally applied to the string, or the string is coated with a resin solution or molten resin before the application of the lubricant.

During playing, the string is subjected to momentary great friction by the ball, so that heat of friction of considerably high temperature develops when the racket strikes the ball, consequently melting the surface of the string locally. Accordingly, every time the ball is struck, fine particles of sand or dust on the surface of the tennis court are carried by the ball and adhere to the molten portion. The portion is therefore subjected to enhanced friction which results in increased abrasion. Furthermore, every time the ball is struck, the ball removes the lubricant from the surface of the string to permit further abrasion of the string.

Improved durabiity of the string is dependent on how to give enhanced abrasion resistance to the surface of the string for the prevention of abrasion. It is desirable to coat the string with a resin having a high melting point and high smoothness so as to diminish abrasion on the string surface, whereas there is no resin which has a high melting point and exhibits good adhesion to polyamide most widely used as the material of the string. Extreme difficulties are therefore encountered in giving improved abrasion resistance to the surface of the string.

It is also proposed to incorporate a metal powder into the surface layer portion of the string as another means for improving the abrasion resistance of the string, but it is impossible to uniformly incorporate the metal powder, so that it is difficult to impart uniform abrasion resistance to the entire surface layer of the string. The proposal, moreover, involves the problem that the metal particles exposed from the surface with the progess of abrasion causes promoted abrasion.

The foregoing problems are not limited only to the strings for tennis, badminton and like rackets but are invariably encountered with the strings of stringed instruments which are subjected to friction and also with fishing strings for use as fishing lines or for fishing nets which are subjected to friction and exposed to sunlight. It is strongly desired in the art to solve these problems.

The present invention, which has been accomplished to overcome the above problems, relates to improvements in strings for rackets, stringed instruments, fishing, etc.

The main object of the present invention is to provide a string for rackets, stringed instruments, fishing, etc. which comprises a main body made of a synthetic fiber and having a surface with high abrasion resistance.

Another object of the present invention is to provide a string of the type stated above having high resistance to light, water and humidity, which, along with the high abrasion resistance, gives greatly prolonged life to the string.

The string of the present invention for use in rackets, stringed instruments, fishing, etc. comprises a main body made of a synthetic fiber and coated with a metal film at least over the surface thereof.

The string main body of the present invention comprises a single monofilament, or a plurality of monofilaments twisted together, or a multiplicity of multifilaments.

According to another embodiment of the invention, the string main body comprises a core in the form of a single monofilament and a plurality of monofilaments wound around the core in the form of at least one layer and bonded to the core with an adhesive.

The metal film coating the string main body is formed only over the surface of the main body, or over the surface of the core and the surfaces of the monofilaments wound around the core.

The string main body of the present invention is made of at least one synthetic fiber selected from the group consisting of polyester, polyamide, fluorocarbon, aramid and polyolefin fibers.

Further according to the present invention, the metal film is prepared from at least one of Al, Cr, Cu, Ni, Ti, Ag, Au, Zn, etc., or is prepared using such metals incombination.

The strings thus constructed according to the invention have the following advantages.

(1) The surface of the string is made of metal in place of synthetic fiber of a film of synthetic resin

conventionally used. This gives the string surface a much higher melting point and also remarkably improved resistance to abrasion, water and humidity.

(2) The conventional string is coated with a protective resin film which is about 20 to about 30 μm in thickness, whereas the metal film can be as thin as about 1/10 to 1/1000 of this thickness. The present string can therefore be made thinner, less bulky and more lightweight as recently required.

(3) The metal film completely shields the string main body from the rays of sunlight, fluorescent lamps, etc., preventing the string main body from deterioration by ultraviolet rays to assure improved resistance to light.

(4) The metal film, which is hard, is resistant to development of minute flaws leading to breaks.

(5) The metal film, which can be very small in thickness, gives the string the same configuration, surface texture and hand as the underlying string main body.

(6) The metal film can be very thin and therefore retains sufficient flexibility. The hardness or stiffness of the string is easily controllable by varying the thickness of the film.

(7) The string of the invention is usable for tennis, badminton and like rackets in place of the catgut and is also widely usable as the strings of stringed instruments, fishing lines, strings for making fishing nets, etc. which must be resistant to abrasion or sunlight.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a perspective view showing an embodiment of the present invention;

Fig. 2 is an enlarged view in section taken along the line II-II in Fig. 1;

Figs. 3 to 8 are enlarged views in section showing other different embodiments; and

Fig. 9 is a perspective view showing a device for measuring abrasion resistance.

Figs. 1 and 2 show a string most typical of those embodying the invention for use in rackets, stringed instruments, fishing, etc. With reference to these drawings, a string main body 1 is made of a single nylon monofilament. The string main body 1 is coated with a metal film 2 of Ni having a small thickness of up to 1000 angstroms to provide a string S.

The metal film 2 is formed over the string main body 1 by metal vacuum evaporation process or chemical plating process. These processes will be described below.

Metal vacuum evaporation process

The string main body 1 is first dried in a vacuum when so required and then led into a vacuum evaporation apparatus. In preparation for the process, the string main body is wound on a feed beam by a warper. Preferably, the string main body is slightly rotated when passing through the evaporation zone so that the metal to be applied will be deposited uniformly on the body. The string main body can be so rotated, for example, by rotating the bobbin to twist the body by an amount of 5 to 10 T/M before winding the body on the beam, and thereafter winding the body on the beam. The string main body then rotates reversely when moving toward a take-up beam through the evaporation zone. The evaporation is conducted in a vacuum of about 2×10^{-4} mm Hg.

Examples of metals useful for evaporation are, besides Ni, Al, Cr, Cu, Ti, Ag, Au, Zn and the like. These metals are used singly, or at least two of them are used in combination. Among these metals, Al, Cu and the like have high thermal conductivity and are advantageous in respect of resistance to heat and chargeability, for example, for racket strings since heat of friction will not build up in the metal during use. The thickness of the deposited metal film 2 is generally up to 1000 angstroms but can be about 100 angstroms when so required. The vacuum evaporation process has the advantage that since the metal film 2 is formed on the string main body 1 which is in a dry state, the resulting body will not absorb moisture which could result in reduced strength. Especially when the string main body is made of polyamide, this is a great advantage.

Chemical plating process

When this process is resorted to, a polyester monofilament 0.8 in intrinsic viscosity and having 90 terminal carboxyl groups is used for forming the string main body 1. The monofilament is first degreased, sensitized, activated and thereafter plated with a metal such as Ni, Cr, Cu, Co or the like. While this process gives a larger thickness, e.g. about 1 μm (10000 angstroms), to the metal film 2 than the vacuum evaporation process, films several micrometers in thickness can also be formed.

When there arises a need to color the metal film obtained by the vacuum evaporation process or chemical plating process, the metal film may be coated with a resin solution containing a coloring agent. Further the metal film may be coated with a smoothening or lubricating agent to impart improved abrasion resistance and surface smoothness to the string.

Strings coated with a metal film according to the invention and conventional strings having no metal film were tested for abrasion resistance, with the results given in Table 1 below.

With reference to Table 1, the symbol A represents string specimens comprising a single polyester monofilament, and the symbol B represents string specimens comprising a single polyamide monofilament 1.0 mm in diameter and serving as a core and 22 polyamide monofilaments having a diameter of 0.16 mm and helically wound around the core in the form of a single layer. Of these specimens A and B, specimens A-1 and B-1 have no metal film, specimens A-2 and B-2 have an Al film with a thickness of 0.1 μm and formed by vacuum evaporation, and specimens A-3 and B-3 have an Ni film with a thickness of 1 μm and formed by chemical plating.

Table 1

Specimen	*Diameter (mm)*	*Abrasion resistance (number of pulls)*
A-1	1.25	4
A-2	1.25	260
A-3	1.251	350
B-1	1.31	2
B-2	1.31	220
B-3	1.311	320

The specimen was tested by the device shown in Fig. 9. With reference to Fig. 9, a table C is provided on the upper side thereof at each end with suitably spaced recessed portions A and projections B. Eleven strings S1 are stretched between the opposed pairs of recessed portions A, A and between the opposed pairs of projections B, B. A single string S2 is positioned across the strings S1 at right angles therewith, under the strings S1 extending between the pairs of recessed portions A, A and over the strings S1 between the pairs of projections B, B. The top of the projection B is 5 mm above the bottom of the recessed portion A. Each string S1 is 20 cm in length. The strings S1 are subjected to a tension of 70 pounds. The string S2 is loaded with a 3-kg weight attached to one end of the string S2. The other end of the string S2 is connected via a counter G to the free end of an arm F attached to a motor E. In this state, the arm F is revolved at 1 revolution per second to repeatedly pull the string S2 with an amplitude of 20 cm in frictional contact with the strings S1 to count the number of pulls when one of the strings S1 broke. The greater the count, the higher is the abrasion resistance of the specimen.

The following specimens were also tested for resistance to light.

Specimen I

A string according to the invention comprising a string main body 1.35 mm in diameter and coated with an Ni plated film having a thickness of 0.5 µm. The main body comprises a single polyamide monofilament having a diameter of 0.98 mm and serving as a core, and 22 polyamide monofilaments having a diater of 0.16 mm and helically wound around the core in the form of a single layer.

Specimen II

A conventional string having a diameter of 1.39 mm and prepared by coating the same string main body as above with molten polyamide resin.

A 40-cm length of each specimen was placed into a light resistance tester equipped with two fluorescent lamps, 30 W and 20 cm in diameter, and was continuously irradiated with the light source at a distance of 10 cm therefrom. The interior of the tester was maintained at a temperature of 20°C and humidity of 65%.

Table 2 shows the results, indicating that the string of the invention has outstanding resistance to light.

Table 2

Days	*Tensile strength in straight state (kg)* 0 day	After 7 days	After 14 days	After 21 days	*Tensile strength in knotted state (kg)* 0 day	After 7 days	After 14 days	After 21 days	Diameter of specimen (mm)
I	72	72	72	72	44	43	43	43	1.35
II	72	68	66	65	44	37	33	31	1.39

Table 2 indicates that when the string main body is made of polyamide, the knot strength of the conventional string decreases about 10 to about 20% owing to the absorption of moisture, whereas the metal film coating the main body according to the invention almost completely precludes strength reduction.

Other embodiments of the invention will be described below briefly with reference to Figs. 3 to 8.

Fig. 3 shows a string S comprising a main body 5 coated with a metal film 6 of Ni having a small thickness of up to 1000 angstroms. The main body 5 comprises a single thick nylon monofilament serving as a core 3 and a multiplicity of thin nylon monofilaments 4 wound in a layer around the core 3 and bonded thereto with an adhesive.

Fig. 4 shows a string S comprising a main body 10 and an Al film 11 coating the main body and having a small thickness of up to 1000 angstroms. The main body 10 comprises a single thick polyester monofilament serving as a core 7 and coated with an Al film 8 having a small thickness of up to 1000 angstroms, and a multiplicity of thin nylon monofilaments 9 wound around the film 8 in the form of a single layer and bonded to the film with an adhesive.

Fig. 5 shows a string S comprising a main body 14 which includes a single thick nylon monofilament serving as a core 12 and a thin Ni film 13 coating the core 12 and up to 1000 angstroms in thickness. A multiplicity of thin nylon monofilaments 15 each coated with a thin Ni film 16 of up to 1000 angstroms in thickness are used as winding elements 17. These elements 17 are wound in a single layer around the main body 14 and bonded thereto with an adhesive.

Fig. 6 shows a string S comprising a main body 19 in the form of a thick nylon monofilament serving as a core 18. A multiplicity of thin nylon monofilaments 20 are each coated with a thin Cr film 21 of up to 1000 angstroms in thickness and serve as winding elements 22. These elements 22 are wound in a single layer around the main body 19 and bonded thereto with an adhesive.

Fig. 7 shows a string S comprising a main body 24 formed by twisting together a multiplicity of thin polyester monofilaments 23, and a thin Ni film 25 coating the main body 24 and up to 1000 angstroms in thickness.

Fig. 8 shows a string S comprising a main body 27 formed by twisting together a multiplicity of nylon multifilaments 26, and a thin Cr film 28 coating the main body 27 and up to 1000 angstroms in thickness.

Although not shown, a multiplicity of thin synthetic monofilaments each coated with the desired metal film may be twisted together to form a string main coated with metal.

Any string of the foregoing embodiments is exceedingly superior to the conventional string having no metal film in respect of resistance to abrasion, light and moisture, tensile strength, etc.

While the present invention has been described above with reference to the preferred embodiments of the invention, these embodiments are given merely for illustrative purposes and are in no way

limitative. Various modifications and alterations within the definition of the appended claims are therefore included within the scope of the invention.

CLAIMS

1. String comprising a body of synthetic fibre coated with a metal film over at least part of the surface thereof.

2. String as claimed in claim 1, wherein the body comprises a monofilament.

3. String as claimed in claim 1, wherein the body comprises monofilaments twisted together.

4. String as claimed in claim 1, wherein the body comprises multifilaments twisted together.

5. String as claimed in claim 1, wherein the body comprises (a) a core of monofilament and (b) monofilaments wound around the core in the form of at least one layer; and wherein the metal film is formed over the surface of the core and over the surfaces of the monofilaments wound around the core.

6. String as claimed in claim 1, wherein the body comprises (a) a core of monofilament and (b) monofilaments wound around the core in the form of at least one layer; and wherein the metal film is formed over only the exposed surfaces of the monofilaments wound around the core.

7. String as claimed in any of claims 1 to 6, wherein the synthetic fibre is one or more of polyester fibre, polyamide fibre, fluorocarbon fibre, aramid fibre and polyolefin fibre.

8. String as claimed in any of claims 1 to 7, wherein the metal is Al, Cr, Cu, Ni, Ti, Ag, Au and Zn, or at least two thereof in combination.

9. String substantially as hereinbefore described with reference 'to and as shown' in Figures 1 and 2, Figure 3, Figure 4, Figure 5, Figure 6, Figure 7 or Figure 8, of the drawings.

10. A racket whose string is string as claimed in any of claims 1 to 9.

11. A stringed instrument whose string is string as claimed in any of claims 1 to 9.

12. A fishing line made of string as claimed in any of claims 1 to 9.

13. A fishing net made of string as claimed in any of claims 1 to 9.

14. A filament for use, inter alia, as a string for a racket, as a string for a stringed instrument, as a fishing line, or in making fishing nets, the filament comprising a body of synthetic fibre coated with a metal film over at least part of the surface thereof.

Printed in the United Kingdom for Her Majesty's Stationery Office by the Tweeddale Press Group, 8991685, 9/87 18996. Published at the Patent Office, 25 Southampton Buildings, London WC2A 1AY, from which copies may be obtained.